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**Los Alamos National Laboratory** Advancing National Security Through Scientific Inquiry

# why

**nuclear inspectors  
train by playing  
video games | pg. 10**



**In this Issue** Plans to reduce LANL's environmental impact | pg. 16

 **Los Alamos**  
NATIONAL LABORATORY  
EST. 1943

## About this issue

Why would a graphic artist choose to work at Los Alamos National Laboratory over DreamWorks or Pixar? Why would a team of scientists and engineers play games to make the world a safer place? We'll introduce you to an unlikely team working (and playing) together to blend the real world with the virtual one. Step into the best of both on page 10.

In your own corner of the world, you may notice fewer copies of *Why* magazine in your workplace—starting with this issue, you will only be mailed a printed paper copy if you choose to subscribe. Even if you opt to receive just the PDF version, you'll still need to subscribe if you'd like us to e-mail you future issues. To receive the printed copy, PDF, or both, please visit [www.lanl.gov/whysubscribe](http://www.lanl.gov/whysubscribe). We do plan a more usable and appealing online presence beyond the PDF.

Please help spread the word to your colleagues who may not have received this issue because they did not subscribe.

Thank you for your continued feedback. We take your suggestions seriously and have incorporated several into this issue, including greater emphasis on answering the question “why?” We also have several story ideas in the queue for future issues. Though we can't promise to apply every suggestion, it's helpful for us to know what you think about form and content.

Keep the ideas and comments coming by e-mailing [why@lanl.gov](mailto:why@lanl.gov). We can't be everywhere so we hope to rely on you, our readers, to uncover interesting stories and photos from across the Lab.

*Why magazine is a quarterly publication primarily for employees and retirees of Los Alamos National Laboratory.*

[www.lanl.gov/news/pubs.html](http://www.lanl.gov/news/pubs.html)

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**Cover:** Kelly Michel visits a virtual world created by photographer Sandra Valdez and graphic artist Adam Watkins.

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## Mary Hockaday

*Deputy Associate Director, Weapons*

## What are some of the biggest changes at the Lab since you began here as a student in 1980?

Changes occur as you progress in your career as well as changes in the Laboratory. I started my career as a summer student working on X-ray detectors that fit on the tips of rockets. These days, with the satellites and the Space Shuttle and the Hubble telescope, you don't have to do that as much. That has really changed.

Another big difference is the male-to-female ratio in the Weapons Program. I will always remember the first day I showed up at Nevada Test Site. I was there with a tech, and we were carrying diagnostic equipment for installation on a large testing rack. The foreman comes up to me and says, "Who the hell are you?" I say, "Ah, I'm a physicist." He goes, "Like a Ph.D.?" And I say, "Yeah, like a Ph.D." And he goes, "Ohhh." You could hear him go through all seven or eight sections of the rack whispering, "There's a woman on the rack, behave yourself, don't swear."

*"When there's a break during a big meeting if there are more than two women in the bathroom, I'll say, 'Networking opportunity!'"*

## Is it just that you are not *one* any more, or have attitudes changed?

I think it's both. The numbers have increased. You see females in engineering, you see them in design, and you see them in experiments. I have simple thresholds for whether we are making progress. When there's a break during a big meeting if there are more than two women in the bathroom, I'll say, "Networking opportunity!"

## What inspired you to get into science, but even more specifically this field, when you were the only one in the bathroom?

I don't think it was conscious. The first step is getting into a technical field, like physics.

I became an exchange student my senior year in high school and went to an all-girls public high school in Japan. There was a physics teacher there who really loved the subject. You could tell. But the kids could

care less about physics. Because I was having a language problem, not knowing much Japanese, I spent a lot of extra time with this professor, or *sensei*, which means teacher, trying to get the principles down.

By the end of the semester I believe I paid him back two ways. One way was that I got the highest grade on the final, even though it was in Japanese. The other was that it turned out I was the only student he ever had who went on to a graduate degree in physics.

## Did you always want to come to Los Alamos?

I knew of Los Alamos, but I never really thought of the Lab until I was in college. A professor at the University of Hawaii's X-ray laboratory encouraged all of us to apply for various programs. There were three of us who applied during my senior year in college. One was my boyfriend, who turned out to be my husband. The second was my husband's officemate. I was the third. We all applied to Los Alamos and Livermore. Bruce Young got a job offer at Livermore; my husband, Bob, got a job offer at Los Alamos; and I got job offers at both. I had to decide whether I was going to go to Livermore with Bruce, or Los Alamos with my boyfriend. Guess what I did?

## What are some of the technical achievements you're most proud of in your career?

I am very proud of fielding the highest resolution X-ray spectrometer on a nuclear test. I am also very proud of helping solve some major problems at DARHT while I was the program manager and division leader. I felt I was instrumental working with the team to convince headquarters that we needed to continue to move toward our goals. Two or three years ago when we actually got the four pulses, it was such a great feeling.

## What is one of the most challenging parts of your job?

It's very difficult to "projectize" a science campaign for an unexpected result. Because the unexpected result under that sort of a framework may look like a failure. And it isn't! The fact is, you have to recognize that the work you have laid out in that campaign to get to that answer is projectized. You have to plan it, it has to be cost effective, etc. But you cannot plan on the answer. Sometimes when we or others write milestones, people go that one step too far and try to "require" a physics outcome that just may not be possible—because it is owned by Mother Nature.



Photo by Sandra Valdez

*“Our goal is to treat our challenges as opportunities.”*

at it and it will be easier and smoother. We are making progress, we have been doing it for a while, but we still have a little ways to go.

### **What big changes do you anticipate in your near future?**

I look for opportunities to contribute. I do believe that as we move to having a new director, there will be team changes, and there will be more opportunities and challenges. Our goal is to treat our challenges as opportunities.

### **How did living and studying in Japan affect your outlook as a national security professional in the Weapons Program?**

While I lived in Japan, I went to Hiroshima with my host family. At Peace Park, we all read the written material, which appeared in English as well as Japanese. When we finished our visit, their response was, “That was really terrible.” My response was, “I hope people don’t forget.” It was, of course, devastating. And it’s also crucial that the people of the world never forget what happened at Hiroshima and Nagasaki. To me, deterrence only works if you never forget and people believe you have the ability to do it again. ■

### **What is your perception of how the Lab, as a whole, is maintaining a balance between doing the science, but also the safety, security, and other types of regulation?**

Remember when you were a little kid and you got a crayon and a coloring book? The goal wasn’t to color within the lines. It was to get color on the page. When you start coloring within the lines, it’s harder, it takes practice. As you got used to it, you got better at it. I think we are in that struggle where we are used to coloring on the page and we are being asked to color within the lines. As a function of time we will get better



Mary Hockaday with members of her Japanese host family and teachers from Shizuoka Johoku High School, along with a yearbook photo from her time in Japan (circa 1975).

# Local Artisans Light the Way

by Tatjana Rosev



community

**Firefly Lighting, Inc., a local company known for its unique custom fixtures, has come a long way from crafting nightlights and candleholders from recycled metal.**

In 2008, the firm reached sales of almost a million dollars after landing several larger contracts. Most prestigious among these was an arrangement with Hilton Hotels & Resorts to provide lighting for the quarter-billion-dollar Buffalo Thunder Resort & Casino in Pojoaque Pueblo, said co-owners Kathleen Wilde and (pictured on page 7) John Zubchenok.



Photo by Jeff Berger

“We did about 1,500 light fixtures for the resort—everything from small wall sconces to chandeliers,” said Zubchenok, a tall, sandy-haired former New Yorker.

“We also did the ‘trees of light’ sculptures made from metal and glass in the hotel lobby,” he continued. “We worked closely with Pueblo Governor George Rivera, who’s an incredible artist himself, to realize his vision.”

## Origins and evolution

Noting that “We never thought we’d expand like this,” Zubchenok remembers how it all started. “I was working for an interior design store and fiddling with metals after work and on weekends to supplement my income,” he said. “When the store closed in the mid-90s, I took a leap of faith and started a little outfit, called Shining Hearts, with Kathleen. We made folk art items from recycled metal.”

When orders started rolling in, Wilde and Zubchenok hired another worker and changed the company’s name to Firefly Lighting. That was 16 years ago.

Based in Pojoaque, Firefly Lighting now employs six workers and offers a wide range of custom lighting products. “I get my inspiration from the artistic traditions of the Southwest, as well as from contemporary, medieval, and Old World motifs,” Zubchenok said. “Design just seems to come natural to me.”

In addition to light fixtures, the company offers decorative ironwork and home accessories made from recycled metal. “We take great pride in our work,” Zubchenok continued. “Every piece is made one at a time, not on an assembly line, and that’s what discriminating customers value.”



Photo by Jeff Berger

While Zubchenok handles the design side of the company and interacts with customers, Wilde, a computer whiz and talented writer, puts together financial plans, does the marketing, and draws in funding. “We’re a great team; we really complement one another,” said Zubchenok, smiling.

## Lab helps boost output and profit

As the firm took off, Zubchenok and Wilde faced a new challenge: how to produce more of their line of standardized features while retaining high levels of craftsmanship and customer service. Fortunately, they heard about the New Mexico Small Business Assistance Program at the Laboratory, and asked whether they qualified for expert help.

Through the NMSBA Program, the New Mexico Manufacturing Extension Partnership provided the training and operational assessments that Zubchenok and Wilde needed to improve operations and expand their business. Lean manufacturing training enabled the owners to streamline their company, and make it a safer place for their master craftsmen to work their magic.

## *“Green before it became chic”*

“We made small, systematic, and incremental improvements, which allowed us to provide a more efficient and safe facility for our production,” Wilde said.

The owners, who were “green before it became chic,” were especially impressed with the environmentally friendly suggestions NMMEP representatives made. “We learned how to produce more with existing resources by reducing waste and developing an ordering system for waste,” Wilde noted.

Wilde, a Tesuque native with degrees in everything from geography to computer-aided design and management information systems, also was pleased with NMMEP’s ideas about how to beef up their online presence. “They analyzed our website and made some great improvements, which ultimately allowed us to reach a much larger market,” she explained.

NMMEP representatives also were sensitive to the needs of Firefly Lighting’s employees, Zubchenok said. “We have a predominantly Spanish-speaking workforce, and NMMEP used a bilingual employee, Claudia Serrano, who translated for those employees so that they, too, could be involved in the process,” he explained.

One worker who benefited from lean manufacturing training is Daniel Aras. Originally from El Salvador, this master craftsman likes to sing as he works with iron and other metals. He’s been with Firefly since 1996.

Another employee who participated in the training is Alberto Orono, who’s from a small mountain village in Mexico. “Alberto has been with us since 1997,” Zubchenok said. “He’s an expert craftsman who uses a jeweler’s torch to create the intricate designs that you see on most of our lighting fixtures.”

Improvements based on Laboratory-sponsored training led to an increase in productivity on all levels and an increase in profitability of their products, Zubchenok said. “That includes a 10 percent increase in sales and a 30 percent improvement in on-time delivery of products,” he said.

“We’re in a really good place right now, and that’s thanks, in part, to the great help we received from the Laboratory,” Zubchenok smiled. “They really helped us get to that next level.” ■



*Northern New Mexico Connect is the primary economic development investment channel for Los Alamos National Laboratory and its operator, Los Alamos National Security, LLC. In addition to New Mexico Small Business Assistance Program, programs include:*

- *LANS Venture Acceleration Fund, which invests up to \$100,000 in Northern New Mexico businesses for projects that seek to commercialize inventions and startups;*

- *Springboard, which provides expert coaching for companies facing strategic decisions;*
- *Market Intelligence, which helps small businesses and entrepreneurs by conducting market research for them;*
- *Entrepreneurial Networking, which connects small businesses and entrepreneurs to community resources.*

*Northern New Mexico Connect also helps build the region’s entrepreneurial culture by hosting numerous networking and educational events.*

## Getting Their Game On

*Nonproliferation team teaches nuclear safeguards using 3D game technology*

by Nancy Ambrosiano





**In a small office trailer perched on a dusty canyon edge, an unlikely team of video gamers, scientists, and engineers has gathered to make the world a safer place.**

Computer screens, sometimes ganged four to a desk, show a virtual world packed with trucks and nuclear portal monitors, the inner workings of nuclear reactors, and the more prosaic stairways and halls that lead from one imaginary laboratory or reactor space to another.

The click of the mouse, the hum of the hard drives, and the easy banter among friends belies the fact that the product of this work might help prevent a nuclear catastrophe.

The synthetic worlds of the team, led by Kelly Michel of Safeguards and Security Systems, are designed to give the International Atomic Energy Agency's safeguards inspectors and other students of nuclear safety a preview of the complex environments in which they are expected to function.

*“Mental preparedness is a big part of achieving success in the conduct of any mission.”*

Inspectors travel all over the real world, potentially walking through dozens of facilities with nothing but a pad of paper and a pencil, so Michel (pictured on the cover) says it is critical that they are trained in cyberspace beforehand to make sense of the visual chaos.

“Mental preparedness is a big part of achieving success in the conduct of any mission,” she said.

“It’s natural for the human brain to be swamped, over stimulated, and unable to separate important from unimportant artifacts in a tense situation. That is not what you want to have happen when you have folks going into emergency situations—or situations where you have limited access or time to spot anomalies that could mean bad things are afoot.

“If you can rehearse a task time and time again, in a nonthreatening environment such as that provided by an immersive virtual reality exercise, you end up doing a better, more effective, thorough job when you arrive at the real scene. Metrics from various studies show this is a fact,” said Michel.

Brian Boyer, also of Safeguards and Security Systems, has developed a partnership with Pennsylvania State University’s Department of Mechanical and Nuclear Engineering. The goal is to build course curricula by incorporating virtual environments to render more realistic and understandable the safeguards concepts being studied in a Penn State graduate-level nuclear engineering course.



"The ability to immerse students in a facility that in real life would be nearly impossible to access has been invaluable to me," Boyer said.

LANL's virtual team created exercises in international safeguards for Boyer so that he could walk students through mock IAEA inspections of a gas centrifuge enrichment plant and a light water reactor to bring classroom concepts to life.

Creating a virtual nuke plant might seem like a no-brainer, given the scenery through which players of post-apocalyptic video games operate. But for this team, the information has to be spot on, with exactly the same bar codes, warning signs, and building layouts as the real deal. In one training scenario, a corner cabinet contains PDFs of real documents an inspector could find there, so the "game" is in some respects a cross between a physical trainer and an online library.

### Being "in VISIBLE"

Another scenario has a potential real-life scene of a Denver-area highway and mountain tunnel, with traffic passing through radiation detectors to find a potential maker of dirty bombs.

The player finds one car that sets off the sirens and red lights of the detectors, then has to interact with the driver to determine if he, or the car, is carrying hot materials.

The computer picks a different outcome each time, so students find that on their first try the driver is merely a

medical patient with radioisotope treatments causing the detector signal, and the next time he's a bomber with a trunk full of hazardous material bound for the big city.

The key to the project is the team behind the screen, called VISIBLE, for Virtual Simulation Baseline Experience, where nuclear engineers, computer scientists, artists, and animators take turns adding their magic.

A random sketch on a napkin, accompanied by some hand-waving on the part of a passing researcher, is manipulated, textured, corrected, and perfected. In time, it becomes not a penciled collection of thoughts, but a crisp, three-dimensional creation, whether it's a radiation detector, a nuclear fuel rod, or a room full of nuclear centrifuges.

"Finding the right people to do this work is the real challenge. At first, we tried to turn engineers into artists but quickly found that was not the best choice," Michel said. "The 3D computer graphics tools that we use are monumentally sophisticated and powerful, and not something you pick up and use effectively right out of the box. It takes years of training to develop expertise with the tools and the requisite understanding of geometry, form, and function."

"We found the best choice was to bring in educated professionally trained computer graphics artists who spend four years learning how to use these tools. These are the same folks who would work at places like Pixar and DreamWorks. We then pair the artists with engineers and scientists, and the results produced are visually amazing, as well as information rich." ■

## The Team Behind the Screen

*The team that uses 3D game technology to teach inspectors key aspects of nuclear safeguards is itself multidimensional.*

*The core individuals (here with Kelly Michel in the middle) who comprise the Virtual Simulation Baseline Experience (VISIBLE) include:*

- *Elise Elfman, a graduate computer graphics artist;*
- *Adam Watkins, a leading expert and professor of computer graphics (currently on sabbatical from University of the Incarnate Word) who has written several textbooks on the subject;*
- *Brian Dickens, an expert software and robotics engineer; and*
- *Jacob Green, an award-winning, world-class computer graphics artist.*

*The team's immersive visualization framework is ideal for illustrating complex concepts and scientific ideas that may otherwise go unappreciated for their elegance and strength. Making those ideas "visible" helps make them understandable.*

*Much of the LANL mission pertains to training and education, not only of peers and sponsors, but of the public as well. Because of the unique blend of expertise within the VISIBLE team, they work easily and naturally with the larger Labwide team of scientists, engineers, and researchers.*

*View the YouTube video and meet the VISIBLE team: <http://tiny.cc/toip3>*



*These are the same folks who would work at places like Pixar and DreamWorks.*

# Reach for the sky

*New petascale trilab supercomputer designed from the ground up to run the largest and most demanding workloads ever*

by Kevin Roark



It's called Cielo, and it's the product of a strong partnership that includes computer manufacturer Cray, Inc. and two National Nuclear Security Administration laboratories, Los Alamos and Sandia. It's a petascale supercomputer, currently operating at 1.03 petaflops or 1.03 million-billion calculations per second—and it's ready for an upgrade to 1.37 petaflops/s in fiscal year 2011. *Cielo* is Spanish for sky.

The Cielo system does more than provide large computing production capability. It focuses on increased performance of computer applications and easy migration of existing integrated weapons codes.

Although it's not designed to break any High Performance Computing (HPC) TOP500 speed records—it's currently ranked 10th on the list—it has broken many others.

It's the first "capability" supercomputer in the NNSA complex to go from contract award to deployment in less than a year. And it's far more energy efficient than previous Advanced Supercomputing (ASC) capability machines.

Along the way the Cielo team met every original schedule requirement projected 18 months in advance and came in on budget at \$72 million for the entire platform, including the upgrade and the 10-petabyte file system supplied by Panasas, Inc.

"Cielo enables our researchers and scientists to increase their understanding of complex physics and improve confidence in the predictive capability for stockpile stewardship," said Don Cook, NNSA's deputy administrator for defense programs. "Ensuring that our nation has cutting-edge supercomputing platforms to apply to our stockpile stewardship program is a key element of NNSA's efforts to implement the President's nuclear security agenda."



In February 2011, the Cielo system received security accreditation to operate in the classified environment for user applications in the final stages of its shakedown period.

Three large, complex computer simulation problems—one each from Los Alamos, Lawrence Livermore, and Sandia National Laboratories—were selected to run on Cielo before it becomes available for wider use by the weapons programs in June 2011. The security accreditation also allowed access to Cielo by a much larger set of application developers. They can now use Cielo to port their codes, debug, and scale before proposing large simulation projects using the allocation of resources for ASC capability machines.

*The Cielo team met every original schedule requirement projected 18 months in advance and came in on budget. . . .*

"Right now it's running a full 3D hydrodynamic problem that's been on hold, waiting for computers to advance enough to handle its size and complexity," said John Morrison, High Performance Computing division leader. "This code is so big no other machine could handle it, and so far it's performing exceptionally well."

In fact, says Manuel Vigil, also of High Performance Computing, Cielo's capability will allow application users to think of new, alternative ways to solve some of the most complex problems in stockpile stewardship.

"Cielo is not an advanced architecture like Roadrunner," said Vigil, "it's based on proven technology using new processors and the latest generation of system interconnects. But it's designed from the ground up to be a large HPC system—rather than a traditional 'cluster'—making it capable of running extremely large, complex codes very efficiently."

Cray was selected to build Cielo last spring. The Cielo contract was a highly competitive procurement that included technical evaluation by experts from all three labs. Design, procurement, and deployment were accomplished by the New Mexico Alliance for Computing at Extreme Scale (ACES), a partnership of Los Alamos and Sandia.

According to Vigil, success in fielding the Cielo system will also give ACES a solid route to eventually reach for the next grand computing challenge, the exascale—1,000 times faster than the petascale.

And for the first time in a long time, the Cielo machine is something more to look at than a series of tall, black computer racks. "Cray has used graphics on their machines for some time now," says Vigil. "But this is the first Cray at Los Alamos with a nice graphic on the side. It depicts a New Mexico sky." The photograph on Cielo was shot by the Lab's Andy White.

Vigil jokes that one of the hardest challenges about getting Cielo up and running was naming it and creating a logo. "We originally thought of calling it 'Zia,' then changed that to 'Mesa,' and eventually settled on 'Cielo,'" he said. "Then one day while running on my treadmill I saw a Balloon Fiesta picture and thought that might be a good way to represent reaching for the sky, going higher and farther. Later, we saw Andy's picture and knew it would be perfect." ■



## **An audacious goal**

*How LANL plans to reduce  
environmental impacts, and  
why it matters so much*

by Fred deSousa

Photo by Richard Robinson

**In 11 places on Lab property, there are pipes that sometimes send water into canyons. In some cases, the water is cleaner than drinking water.**

Like a medium-sized town, each year the Lab discharges roughly 150 million gallons of water down canyons—enough to supply nearly 5,000 homes with water for a year. The water comes from many places and does many things. It cools the Lab's supercomputing complexes, it cools the power plant, and it comes out of the sanitary plant that treats water from our toilets and sinks.

Until recently it also came out of the Radioactive Liquid Waste Treatment Facility, after that system scrubbed the water clean of plutonium or other contaminants.

A lot of this discharge comes from cooling towers (such as those at LANL's supercomputing complexes, Technical Area 55, and DARHT), which occasionally must be flushed out in a process called "blowdown." (See sidebar, "How cooling towers work.")

Without extensive treatment by the Laboratory, such water could violate standards in the EPA permit that allows LANL to discharge. The Lab, facing the prospect of more stringent water quality standards when the current permit expires in 2012, must act now.

***"You can drink it, but you can't dump it"***

Consider these examples:

- The Lab wouldn't be allowed to discharge into the environment the very same water that flows from kitchen taps in Los Alamos homes. Why? Too much chlorine.
- Without treatment, water from LANL's own power plant contains too much copper and zinc—not from anything being added at the plant, but from the plant's own internal plumbing.
- At the Los Alamos Neutron Science Center (LANSCE), the problem is arsenic. Again, not from some poisonous experiment, but naturally occurring in potable county water used in that facility's cooling towers.

Mike Saladen shows the main outfall from Technical Area 3.

- Municipal water systems add chlorine to a concentration of about 0.1 parts per million. The discharge standard is 10 times less, 0.011 parts per million. In Los Alamos County, in order to test fire hydrant flow, Lab maintenance crews must dechlorinate water that reaches canyons.
- Polychlorinated biphenyls (PCBs) were once widely used in electrical transformers. Spread worldwide by weather patterns, traces are found everywhere, including in just about any glass of tap water. The Environmental Protection Agency's drinking water limit is 0.0005 parts per million. But the Lab's discharge standard is more than a thousand times lower at 0.0000064 parts per million—the most stringent standard in the nation.

"You can drink it, but you can't dump it," says Denny Hjeresen, LANL's Environmental Protection division leader.

But how can this be?

Most of LANL's canyons are classified as "ephemeral waterways"—they only flow sporadically, during rainstorms or snowmelt. Standards are much tighter for these waterways.

"Because we discharge to dry dirt, whatever the standard is goes right up to the drain pipe," said LANL water quality expert Mike Saladen.

Entities that discharge into permanent bodies of water, such as rivers, receive what amounts to a credit for the mixing that occurs.

Regulators further penalize LANL for Cold War contaminants still remaining in some canyons.

"Our water is pushing whatever's in the canyons downstream," Saladen said.

### **A critical decision**

This is not about toxicity, Lab leaders say. It's about complying with an EPA permit that contains fines of up to \$25,000 per day for violations. Failing to comply can lead to a shutdown of facilities or projects.

"Management made a critical decision," Hjeresen said. "The basis of that decision rests on two options. Number one, you put in a treatment system to meet the standards. Number two, you find a way to stop discharging."

The Lab chose the second option about five years ago. Stop dumping, clean out what needs to be cleaned, and reuse the water.

In 1993, the Lab had 141 permitted outfalls, or places where pipes discharged water to the environment.



Photo by LeRoy N. Sanchez

Since then, that number has been reduced to 11. The Lab's highly ambitious goal, written into its Environmental Management System: Zero liquid discharge by 2012.

"Prevention is seen as a touchy-feely thing to do, but fundamentally, it's a business strategy," Hjeresen said. "Eliminating the discharge to the environment eliminates an ongoing mission liability."

So facilities all across the Lab began making changes. They began evaporating water, either passively with pools or mechanically with large evaporators. They took unused outfalls off the permit.

Even the Radioactive Liquid Waste Treatment Facility, known by some as "the kidneys of TA-55," has stopped regularly discharging water to Mortandad Canyon. While its outfall is still on the permit, RLWTF now uses a mechanical evaporator to get rid of what water is treated.

And with each new EPA permit, standards get tougher and tougher for the water that does get discharged.

"I don't see it changing, either," Saladen said. "The standards will only get more stringent."

But getting rid of the last few outfalls will require even more effort.

## Reducing liquid discharge

The key to reducing liquid discharge will be the expansion of a facility called the Sanitary Effluent Reclamation Facility, or SERF.

Instead of discharging to the environment, the Lab's sanitary wastewater treatment plant will pipe its water to the SERF. The SERF will treat it and send it for re-use in cooling towers.

This move alone will allow the Lab to reuse 300,000 gallons of water per day. That's an Olympic-sized swimming pool every two days, and 120 million gallons per year.

Cooling towers from the Strategic Computing Complex and the Laboratory Data Communications Center will send their water to the SERF, as will the power plant.

"We're buying less water," said Hjeresen. "We're being responsible, and helping meet Executive Order and NNSA sustainability goals by recycling and reusing as much as we can. This one project alone will help meet NNSA's water conservation goals complexwide."

It will take about \$15 million for a 3,000-square-foot SERF expansion, new pipes, tanks, and filtration system. Connections are already in place to the Strategic Computing Center and the power plant.

Temporarily delayed by a "no new projects" edict in the first federal continuing budget resolution for fiscal year 2011, the funding is now secure.

"We're elated," said Andy Erickson, division leader for Utilities and Institutional Facilities. "It has just so many benefits to the Lab. From a water reuse and reclamation standpoint, the SERF will be huge, and it will help us meet this first-in-the-nation PCB standard."

The project is currently scheduled for completion by the end of 2012. Shortly thereafter, the Lab will dramatically reduce liquid discharge, keep only two or three outfalls, and move one step closer to that audacious goal of zero liquid discharge. ■

## How cooling towers work

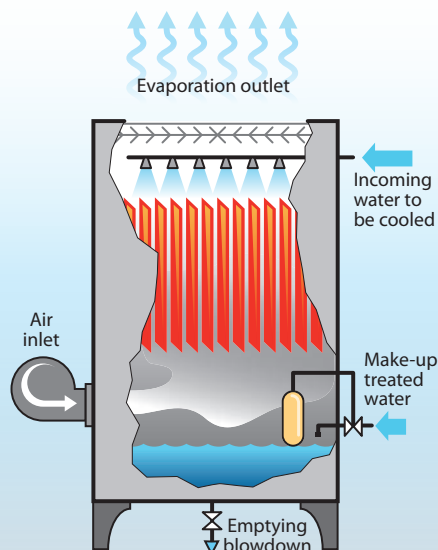
A cooling tower absorbs heat from whatever it's cooling—let's say a computer rack—by circulating water pumped through a heat exchanger.

The heated water is sprayed over the sides of the tower and a fan blows air over them. This cools the water through evaporation and can cause the telltale plume of water vapor coming from many cooling towers.

The cooler water then returns to the heat exchanger to absorb more heat from the computer rack.

Because some of the water is evaporated, the sprayed water in the cooling tower must be flushed out periodically in a process called "blowdown." This prevents silica in the water from concentrating and reducing the efficiency of the cooling process. Blowdowns can send thousands of gallons of water down canyon.

When the SERF facility is expanded, blowdown water from Lab cooling towers will be sent to the SERF, treated, and reused.



LANL's Sanitary Effluent Reclamation Facility, key to reducing the Lab's discharge of liquid.

# Nanotech 101

*How scientists use the smallest scale  
to solve the biggest problems*



**Researchers at Los Alamos National Laboratory are on the verge of something small. And at the Center for Integrated Nanotechnologies Gateway to Los Alamos Facility, smaller means better.**

Nanotechnology—the science of working with materials just a billionth of a meter in size—is a relatively new field. Worldwide, this science of the small is beginning to pay big dividends in terms of addressing some of the most pressing fundamental challenges of the day.

Nanotechnology holds promise to help the United States build energy independence by means of radically more efficient solar panels, or paints that could turn the exterior walls of buildings into giant solar collectors. The science also may provide the key to creating materials that can withstand the brutal radioactive punishment delivered to components in the hearts of nuclear reactors. Nanoscience could lead to incredibly strong and damage-tolerant materials for feather-light vehicles that run for miles on cupfuls of gasoline instead of gallons.

In the realm of health, nanotechnology is being used to develop drugs that pinpoint their targets with the utmost precision—leading to more effective treatments and fewer side effects.

In the national security arena, nanotechnology is at the heart of sensors that can detect harmful chemical or biological agents before they become a threat to humans.

Nanotechnology also is helping us understand the inner workings of cells and cellular processes, and providing new strategies for cleaning up and safeguarding the environment.

*“The width of a DNA molecule is some two and a half nanometers, which is about a thousand times smaller than a single bacterium, or about a million times smaller than a drop of rain.”*

## **How small is a nano?**

Nanotechnologists examine the properties of materials at the nanoscale, which includes sizes from 1 to 100 nanometers. That’s between 1 and 100 billionths of a meter. It’s a scale so small that it’s difficult for most people to comprehend.

Ten hydrogen atoms side by side equal about one nanometer. Each page of this magazine is about 100,000 nanometers thick. The width of a DNA molecule is some two and a half nanometers, which is about a thousand times smaller than a single bacterium, or about a million times smaller than a drop of rain.

A strand of blond human hair is roughly 25,000 nanometers in diameter, 25,000 times wider than the diameter of a carbon nanotube—a material that’s now being routinely used in tennis racquets, composite baseball bats, and certain automobile parts due to its incredible strength and fantastically light weight.

Nanosized particles of titanium dioxide or zinc oxide are used in sunscreen because they are highly effective at reflecting ultraviolet light, but so small that

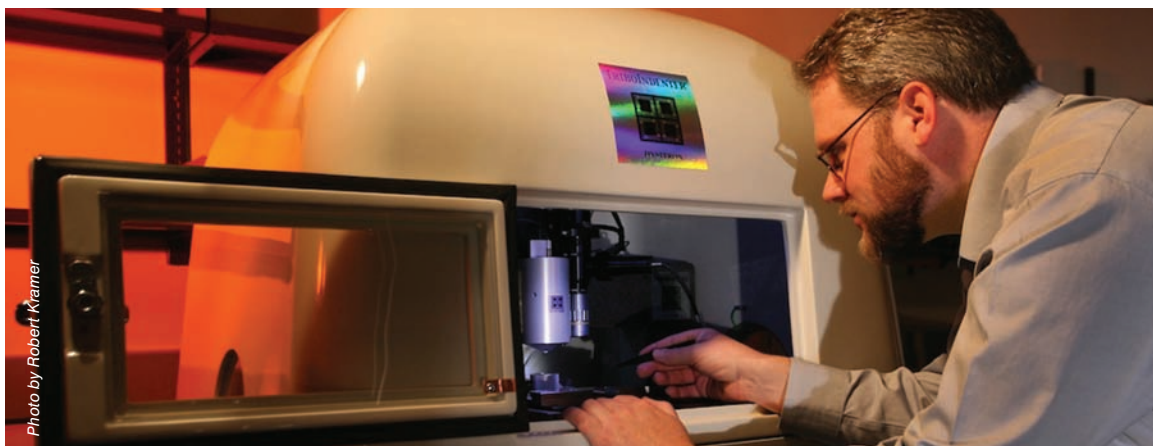


Photo by Robert Kramer

LANL scientist Nathan Mara places a material sample in a nanoindenter. The test instrument drives a tiny diamond tip into the surface of a specimen, displaying the applied force and resulting displacement. With this data, the system determines a material's elasticity, hardness, and other properties.

they're transparent—meaning people no longer need to walk around with “lifeguard nose.” Elsewhere, particles of nanoscale silver are used as topical salves to effectively kill bacteria, while similarly scaled bits of rust exhibit marvelous magnetic interactions that could be exploited to remove arsenic from drinking water.

### On the nanofrontier: “Triple-A” property of self-healing

Among the nanoscale research efforts under way at Los Alamos, scientists within the Center for Materials at Irradiation and Mechanical Extremes (CMIME—see [cmime.lanl.gov](http://cmime.lanl.gov)) are working to develop more robust, self-healing materials for use in nuclear reactors, and other applications—such as defense or transportation—that rely on the integrity of structural materials in extreme conditions. It's an important initiative in the Laboratory's energy-security and national-security missions and science focus on Materials of the Future.

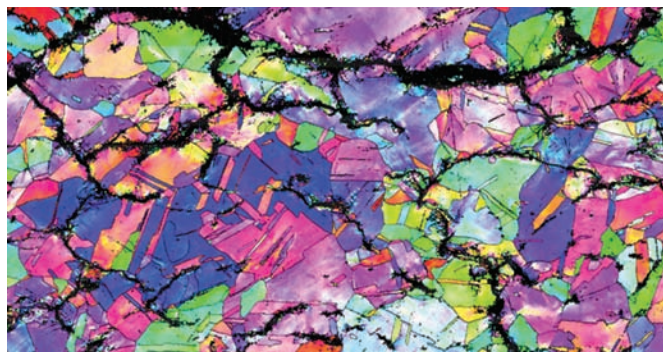
“We are specifically looking at materials at the nanoscale because that is where we find the boundaries between nanograins,” said Amit Misra, a material scientist in the Lab's Materials Physics and Applications Division and codirector of CMIME.

“At this scale, we see excess atomic volume, the space between nanograins that may provide the ‘wiggle room’ within materials that allows them to attract, absorb and annihilate defects—a triad that we call the ‘Triple A’ property of interfaces. This triad is the key concept in the atomic-scale design of self-healing materials.”

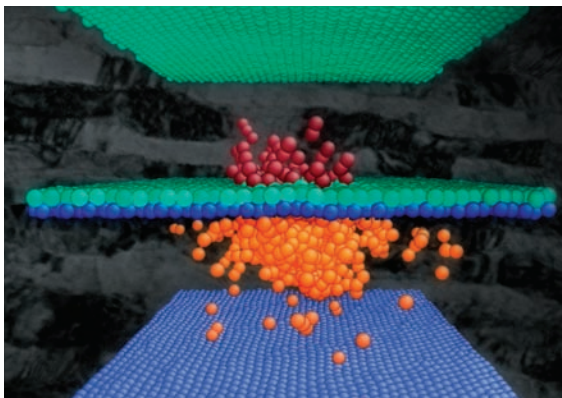
### Nuclear applications of Triple-A attributes

As the tragic 9.0 earthquake in Japan recently illustrated, the ability to create next-generation materials able to withstand the environment within a nuclear reactor and self-repair damage is highly desirable for future nuclear power plants. Use of nuclear power is expected to grow because nuclear power plants can generate electricity without producing climate-altering greenhouse gasses and help wean the nation off near-total dependence on fossil fuels.

Constant bombardment with radioactivity inside a nuclear reactor provides challenges that are nearly perfect for tackling at the nanoscale.



Integrating advanced characterization techniques with high-explosive testing capabilities, LANL's Center for Materials at Irradiation and Mechanical Extremes (CMIME) provides knowledge vital to meeting complex challenges in the nuclear weapons program. Here, orientation-imaging microscopy (OIM) reveals the profound effect of shock-wave shape profiles on damage evolution.



Traditional materials degrade under intense radiation exposure, but certain nanocomposites contain interfaces that allow these materials to self-heal. This image shows radiation-induced damage being absorbed by the interface of copper and niobium.

“If you put a material inside a nuclear reactor, the material ends up getting what could be called a cancer,” Misra said. “You get these voids inside the material that multiply and expand, causing the material to swell and become brittle. What we are talking about doing here is making materials that are immune to radiation.”

When a material is bombarded by radiation, neutrons can jar atoms out of place in the bulk material. If the damage is not mitigated, the materials eventually fail.

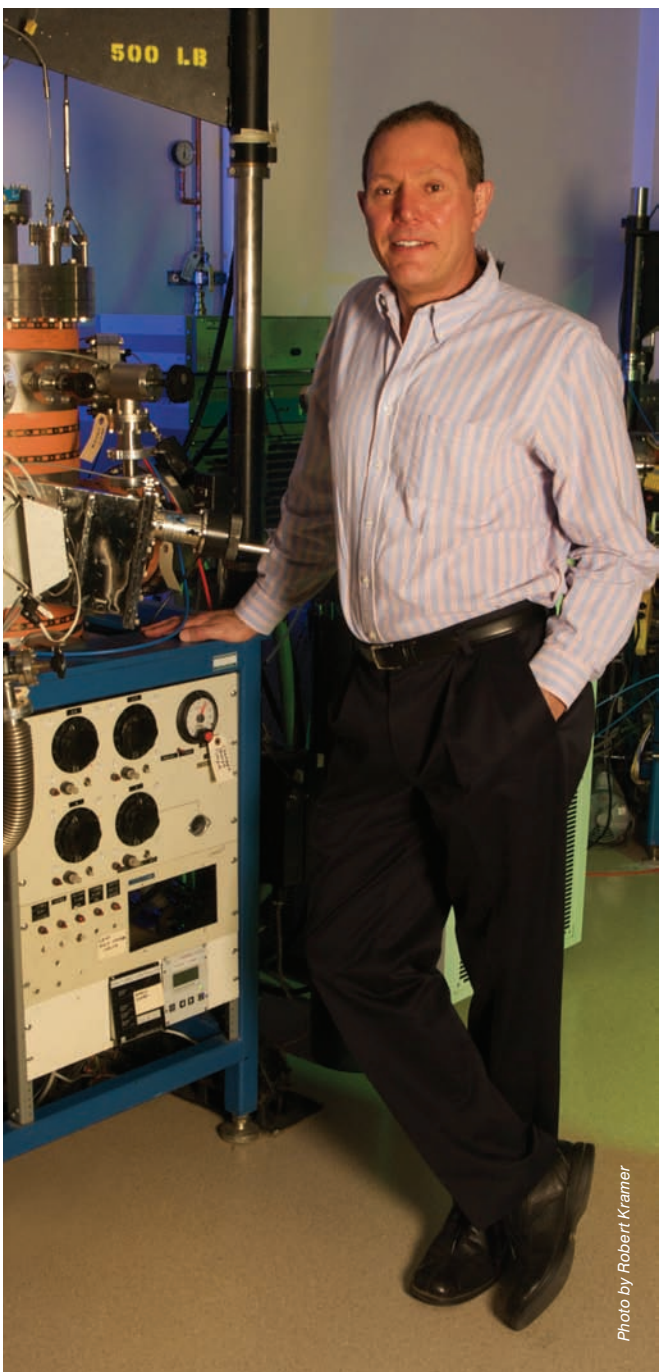
The short lifespan of materials currently used to clad nuclear fuel rods means that only about 5 percent of the fuel can be used before the rods must be replaced. If scientists were able to expand the life expectancy of reactor materials, nuclear power could become cheaper and safer.

Researchers at Los Alamos have noticed that complex interactions at the boundaries of nanosized grains making up certain materials can either lead to longer life or premature death in radiation-damaged materials. In some cases, these grain boundaries act as sinks that attract and absorb displaced particles and later on reverse damage by ejecting particles (interstitials) into the empty voids, or vacancy clusters, created during displacement.

“Not all boundaries do this,” said Michael Nastasi, director of CMIME. “Our job is to figure out which boundaries have this ‘Triple-A’ attribute and then find ways to make more of them. Materials with the ‘Triple-A’ pedigree seem to heal damage, while materials with boundaries that do only one or two of these functions seem to make it worse.”

*“The key to the future is maintaining our competitive edge in science.”*

Mike Nastasi, director of the Lab’s Center for Materials at Irradiation and Mechanical Extremes (CMIME), is a Fellow of the American Physical Society, the Materials Research Society, and LANL.



## Nano Advances by Dint of CINT

*The Center for Integrated Nanotechnologies (CINT) is a Department of Energy Office of Science user facility. It's operated jointly by Los Alamos and Sandia National Laboratories, each of which is home to a portion of the laboratory and office space: the Gateway to Los Alamos Facility and the Core Facility, respectively.*

*CINT's objective is to foster scientific discovery that enables the integration of nanoscience concepts and structures into the micro and macro worlds.*

*As a national user facility, CINT provides access to its staff and capabilities for nonproprietary nanoscale science research at no fee. Proprietary research may be conducted under a full-cost recovery agreement.*

*CINT focuses on four major thrusts:*

- Nanoscale electronics and mechanics
- Nanophotonics and optical nanomaterials
- Soft, biological, and composite nanomaterials
- Theory and simulation of nanoscale phenomena

## Maintaining a competitive edge

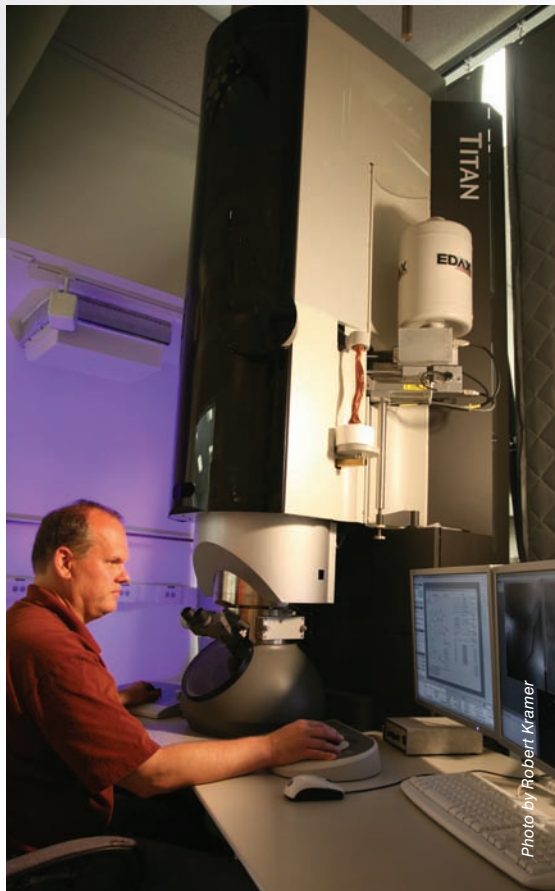
The scientists at CMIME, the Center for Integrated Nanotechnologies, and elsewhere throughout the Laboratory are attempting to work out the design rules that will allow people to synthesize materials of the future. Their goal is to provide within a few years a proof of concept for next-generation materials.

The next step will be the ability to create and test bulk-quantities of such materials.

"We are working to provide the scientific cornerstone of MaRIE, the Laboratory's proposed signature facility that will look at Matter-Radiation Interactions in Extremes," Nastasi said.

The MaRIE facility is critical if America is to remain on the forefront of national security science and basic science.

"It is crucial for us to have a facility to make bulk materials and test them," Misra said. "Otherwise we will publish our results, and then those results will be put on a shelf where they may be picked up by Japan, China, India, or some other nation. The key to the future is maintaining our competitive edge in science." And the key to that edge may be the mastery of nanotechnology. ■



Rob Dickerson uses a state-of-the-art transmission electron microscope at the Electron Microscopy Laboratory managed by LANL's metallurgy group, Materials Science and Technology Division. The lab supports multiple Los Alamos programs, including the Center for Materials at Irradiation and Mechanical Extremes (CMIME).

# What do you do?

## *Jobs around the Lab*

by Ed Vigil

**Marianne Francois works in Computational Physics and Methods. She develops numerical methods and physical models to simulate fluid flows with moving interfaces.**

### **What skills do you need to be a computational physicist?**

You need a very strong background in applied mathematics, computer science, and, in my case, fluid mechanics—the study of gases and liquids at the continuum level and how they move, evolve, and change phase—looking at the boundaries between liquids, solids, and gases.

### **What special training or education do you need?**

I have a doctorate in aerospace engineering from the University of Florida. And I continue learning by taking Lab and University of California courses, when the opportunity arises, in computer science and physics.

### **Why did you choose this field?**

Because I enjoy it. It became my area of interest, when I was working on my master of science degree at Embry-Riddle Aeronautical University and I became interested in the fluid dynamics of bubbles and drops. I also enjoyed computer science, which allowed me to combine the two and develop the algorithms I needed to study this phenomenon.

### **How long have you had this job?**

I started at the Lab in November 2002 as a postdoc, becoming a staff member in 2004.

### **What's the best part of your job?**

The research and science part of it and the opportunity I have to work in a team environment on exciting projects and applications. For instance, when you try an idea for a numerical method, it doesn't always work the first time. But once you're successful and publish your research, it's the satisfaction that comes from having others at the Lab and in the scientific community find value in it. Also, exploring the unknown is something that makes my work very exciting.

### **What's the most challenging part?**

I think science itself requires you to be persistent. Doing research is often rewarding—but challenging as well. And, often, the ever-changing funding to do the research requires you to be flexible and able to work on other projects and research fields.

### **What do you do on your days off?**

As a licensed pilot, I often fly with the Civil Air Patrol, providing emergency services including search and rescue and disaster relief work. In addition, I help the Cadets program, a youth program in the Civil Air Patrol, with aerospace education.

I also volunteer as a presenter every year for Expanding Your Horizons, where I do the Aerospace Workshop with my fellow pilots from the Ninety-Nines, a women pilots organization.

And when I am not busy with my volunteer activities, I enjoy staying active by skiing, hiking, swimming, and playing golf and tennis.



Photo by LeRoy N. Sanchez

Marianne Francois is a computational physicist and spends some of her free time as a Civil Air Patrol pilot.



Photo by Sandra Valdez

John Naranjo balances his serious work protecting the environment with some serious play on his Harley.

**John (Dan) Naranjo works at the Lab's Wastewater Treatment Facility. As general foreman of operations for Maintenance & Site Services—Utilities & Infrastructure, Naranjo leads the team responsible for making sure that the Lab's wastewater is processed, treated, and meets all state and federal requirements.**

### **What skills do you need to be a wastewater foreman?**

Managerial skills, people skills, and the ability to prioritize tasks. The unique thing about wastewater treatment is that wastewater is a living, breathing organism that requires constant attention and monitoring. That requires you to be focused. It is a 24/7 job, and we are always on call to make sure things are working smoothly.

### **What special training or education do you need?**

It is helpful to know chemistry, biology, hydraulics, and have a working knowledge of pump systems. In addition, you need state accreditation in wastewater treatment and lots of experience. We probably have the most level 4 [highest level attainable] operators of any institution in New Mexico. We must meet the permitting requirements put in place by the Feds.

### **Why did you choose this field?**

I got a degree in environmental science and waste management. I discovered that a society that doesn't deal with its waste will be consumed by it, and that's

what really got me interested in choosing this field as a career. Although it may not be a glamorous job, it is a necessary and rewarding one—protecting the environment and assuring water quality for generations to come.

### **How long have you been with the Lab?**

I started here in 2002. Before that I did the same type of work for the City of Española, where I started doing the lab analysis in 1996.

### **What's the best part of your job?**

The people I work with. I don't think I've ever worked with a more enjoyable bunch of gentlemen. They are professional, take their jobs seriously, and are extremely dedicated. You can count on them to be there when you need them.

### **What's the most challenging part?**

The ongoing education to make sure people realize that we're all in this together and we should all take responsibility for what we put down the drain. It's vital to follow all the markings on drains and to pay attention. It is the only process where we at the water treatment plant have no control over the input—yet have to create a perfectly defined output.

### **What do you do on your days off?**

I enjoy spending time with my children, working around the house, and I love to ride my Harley and go on bike runs when I can. ■

## LANL's Security Force Prepares to Protect



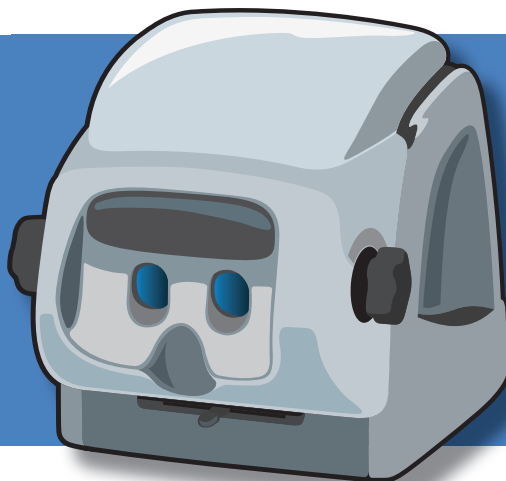
Los Alamos security police officers stay ready for action with a rigorous regimen of instruction, training exercises, firearms qualifications, and physical fitness. Personnel working for contractor SOC Los Alamos train with and deploy state-of-the-art equipment to deter, detect, and defend against ever-changing terrorist threats and malevolent acts. The Lab's protective force consists of highly skilled, highly trained, and motivated security police officers.

Within the protective force, there is a specialized team of tactical response force members proficient in Special Weapons and Tactics (SWAT) to secure the Department of Energy's special nuclear material. The protective force also participates in an annual Security Police Officer Training Competition at the international level, competing against numerous federal, state, and military security teams. ■

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## Off the wall: spot-on vision testing for Lab workers

What's pictured isn't an alien or a Rolodex file. It's the computerized vision tester used by LANL's Occupational Medicine staff.

Far faster and more versatile than the old eye chart on the wall, this portable unit tests a host of functions apart from basic visual acuity. It calculates color, night, and peripheral vision.

Depending on the requirements of a particular type of job at the Lab—for example a quality assurance professional or a protective force officer—this digital device also is capable of readouts for depth perception, binocularity, eye-muscle balance, and more.

The patient, standing or sitting as directed, puts his or her face against the front of the unit, aligning the eyes with the blue oval sockets. Various charts and graphs appear as directed by the OccMed technician, who wields a control box and a stylus.

The product is supplied by Sperian Protection, a unit of Honeywell. Until fairly recently, Sperian's optical business was known as Titmus Optical, based in Petersburg, Virginia. Titmus began in 1908 as a manufacturer of ophthalmic-grade glass lenses and introduced its first vision screener in 1959—some of which are still in use.